

MONITORING PLAN
PROJECT NO. C/S-09
BROWN LAKE HYDROLOGIC RESTORATION

ORIGINAL DATE: April 8, 1997
REVISED DATE: July 23, 1998

Preface

Pursuant to a CWPPRA Task Force decision on April 14, 1998, the original monitoring plan was reduced in scope due to budgetary constraints. Specifically, post-construction fisheries monitoring was omitted and the funds were used to augment the fisheries monitoring on the East Mud Lake project. Water level and salinity will be monitored continuously through 2005. Upon collection and evaluation of this data set, the Technical Advisory Group (TAG) will assist in development of a sampling plan based on an approximate 30% reduction of effort, if technically advisable.

Project Description

The Brown Lake project area encompasses approximately 2,800 ac (1,133 ha) of open water and brackish marsh located in Cameron and Calcasieu Parishes (figure 1). It is bounded on the north by the Gulf Intracoastal Waterway (GIWW), on the east by Highway 27, on the south by oil well location canals and spoil banks and on the west by the Alkali Ditch and is centered approximately at Lat. 30° 02' 35"N and Long. 93° 21' 55" W.

The project area is classified as brackish marsh (O'Neil 1949; Chabreck, 1978) supporting *Spartina patens* (marshhay cordgrass), *Spartina alterniflora* (smooth cordgrass), *Scirpus americanus* (Olney's bulrush) and *Juncus roemerianus* (needlerush) as the dominant emergent vegetation. Submersed aquatic vegetation (SAV) is conspicuous only in the northeastern ponds and is represented by *Ruppia maritima* (widgeongrass) and *Myriophyllum spicatum* (Eurasian watermilfoil). Predominant soil types are Clovelly and Gentilly mucks comprising 28.3% and 42.6% respectively (NRCS 1995). Other soil types are Aquents and Udifluvents that were deposited during construction and maintenance of navigable waterways. Approximately 176 ac (71 ha) of the project area have been restored with the use of dedicated spoil disposal from the Calcasieu Ship Channel. Presently this spoil is concentrated in the east-central portion of the project and is configured into five large cells with levees surrounding each cell. The exterior of the levees has been planted with smooth cordgrass. The interior of the southeastern cell was planted with 21 ecotypes of marshhay cordgrass and 31 ecotypes of *Paspalum vaginatum* (seashore paspalum) by NRCS in 1994 and remains heavily vegetated. The four remaining cells are shallow open water ponds partially inhabited by SAV. The levees are eroding rapidly due to high water levels.

The hydrology of the project area has been altered greatly in the past 50 years. Prior to 1940, water exchange between the interior marshes was primarily by sheetflow over Kelso Bayou and a small bayou linking it to Brown Lake, limiting tidal influence from the Gulf Of Mexico. The Alkali Ditch, constructed in the 1930's for the installation of pipelines, connects Kelso Bayou to the GIWW. The

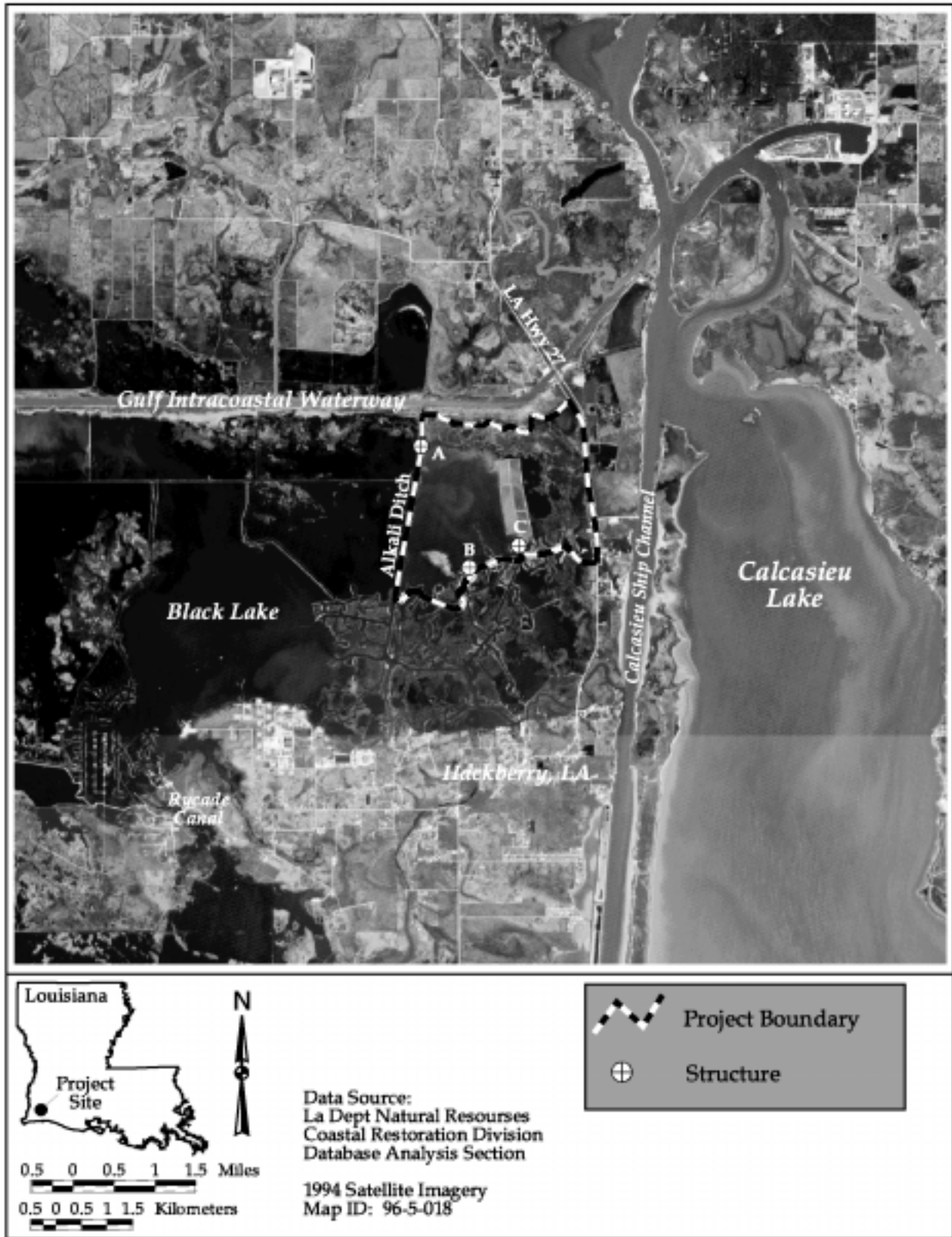


Figure 1. Brown Lake (CS-09) project boundary and locations of proposed structures.

GIWW, constructed in 1915 did not appear to have a major impact on the hydrology until construction of the Calcasieu Ship Channel in the 1940's and its enlargement in the 1960's (USDA/NRCS 1996). The net effect of the channel, maintained at a 42 ft (12.8 m) depth and a bottom of 400 ft (122 m), increases tidal flooding by approximately 1.5 ft (0.46 m) and increases duration of flooding by 10 hours (Suhayda 1994). Impacts from increased water salinity and water level fluctuations have altered the project area from a 92:8 land to open water ratio in 1956, to a 31:69 land to open water ratio in 1995.

The Brown Lake Hydrologic Restoration project is designed to restore the historic salinity levels and circulation patterns to the area by implementing a water management plan. The result of the project plan implementation is an improved hydrologic condition that serves to stabilize salinity and water levels, increase emergent and submersed aquatic vegetation and provides for the restoration, protection, and enhancement of this fragile wetland system.

The Brown Lake Hydrologic Restoration project includes installing and maintaining water control structures, rehabilitating and/or constructing levees and terraces, and planting vegetation. The structures are designed to reduce the extreme fluctuations in salinity and water levels, while providing adequate fresh water flow. The construction of the levees and terraces will increase the marsh to water interface, dissipate wave energy on shorelines, and promote the establishment and growth of submersed aquatic vegetation. The vegetative plantings will provide an additional seed source to vegetate exposed mudflats and help stabilize and protect eroding shorelines. The project features include:

1. Constructing 25,000 linear ft (7,620 m) of earthen terraces planted with a double row of *S. alterniflora* on 5 ft (1.5 m) centers. The terraces will be placed within the shallow areas adjacent to emergent marsh and shorelines to provide tranquil areas for submersed aquatic vegetation to grow. The terraces will be plowed with a terrace plow, or constructed with a dragline or similar machine.
2. Constructing and/or rehabilitating approximately 32,000 ft (9,754 m) of boundary levees along the Alkali Ditch (the western boundary) and the southern boundary of the project.
3. Planting an additional 10,000 ft (3,048 m) of *S. alterniflora* along levees and shorelines as needed.
4. Installing three water control structures at sites A, B, and C (figure 1), corresponding to USDA/NRCS structures 8, 15, and 14, respectively from the Environmental Assessment. The water control structure at Site A will consist of two corrugated aluminum 36 in (0.9 m) pipes with flap gates on the inside (marsh) and screwgates on the outside (Alkali Ditch) and will be managed to allow fresh water from the GIWW enter the project area. The structures at Sites B and C will allow excess water to exit the area while deterring high salinity water to enter the project area in addition

to allowing ingress and egress of estuarine dependent organisms. Structure C will be a 7 ft (2.1 m) wide box structure with a flap gate on the outside of the project area and a variable crest weir on the marsh side. The structure at Site B will be the principle water control structure for the area. It will consist of five 48 in (1.2 m) corrugated aluminum barrels with a flap gate on the outside and a 10 ft (3 m) wide variable crest weir on the inside. Each variable crest inlet section will have a six inch wide vertical slot that will separate the weir inlet section into two bays.

Project Objectives

1. Prevent wetland degradation in the project area by reducing vegetative stress, thereby improving the abundance of emergent and submergent vegetation. This will be achieved through hydrologic structural management to reduce water level and salinity fluctuations.
2. Maintain the project area as brackish marsh.

Specific Goals

The following goals will contribute to the evaluation of the above objectives:

1. Increase emergent marsh vegetation by controlling erosion and reclaiming eroded areas.
2. Decrease annual water level variability, without increasing mean water level relative to the reference area.
3. Decrease annual salinity variability, without increasing mean salinity relative to the reference area.
4. Increase the frequency of occurrence of SAV in the project area.

Reference Area

The importance of using appropriate reference areas cannot be overemphasized. Monitoring on both project and reference areas provides a means to achieve statistically valid comparisons, and is, therefore, the most effective means of evaluating project success. The evaluation of sites was based on the criteria that both project and reference area have a similar vegetative community, soil type, and hydrology.

The reference area was selected to monitor salinity, water level, existing vegetation, SAV and fisheries. It is located just south of the project area bounded on the east by Highway 27, on the north by the project area, on the west by Kelso Bayou, and on the south by an old canal near

Hackberry (figure 1). The proposed reference area is similar in vegetation, soils, and hydrology, but will not be impounded as will the project area. Preconstruction data obtained from the project and reference area will be reviewed to confirm the adequacy of the reference area.

Monitoring Elements

The following monitoring elements will provide the information necessary to evaluate the specific goals listed above:

1. **Habitat Mapping** To document land and water areas and marsh loss rates, color infrared aerial photography (1:12,000 scale, with ground controls) will be obtained. The photography will be georectified, photointerpreted, mapped, and analyzed with GIS by NWRC using procedures as outlined in Steyer et. al. (1995). The photography will be obtained in 1997 (pre-construction) and in 2002, 2008, and 2017 post-construction.
2. **Salinity** Salinity will be monitored monthly at 12 permanent discrete sampling stations within the project and 11 stations outside the project area. In addition, continuous data recorders will be deployed to record salinity at 2 locations in the project area and 3 locations outside the project area. Salinity data will be used to characterize annual variability throughout the project area and to determine if project area mean salinity is not increased relative to the reference area. Salinity will be monitored in 1997-1999 (pre-construction) and in 2000-2005 (post-construction). Upon collection of this data set, the TAG will assist the CRD Monitoring Manager with evaluation of the data and development of a sampling plan based on an approximate 30% reduction of effort, if technically advisable.
3. **Water Level** To monitor hydrologic conditions within the C/S-09 project area and document water levels, water level relative to marsh level will be monitored monthly by reading 5 staff gages inside the project area and 5 outside the project area near proposed water control structures and at continuous data recorders. Water level data will be used to document the annual variability in water level in the project area relative to the reference area. Water level will be monitored in 1997-1999 (pre-construction) and in 2000-2005 (post-construction). Upon collection of this data set, the TAG will assist the CRD Monitoring Manager with evaluation of the data and development of a sampling plan based on an approximate 30% reduction of effort, if technically advisable.

4. Existing Vegetation To monitor the relative species composition and general conditions of existing emergent vegetation within the project area, 30 sampling points will be chosen to document % cover, species composition, and height of dominant plants in plots a minimum of 2.0 m² using the Braun-Blanquet method outlined in Steyer et al., 1995. Two east-west transects and two north-south transects will be established uniformly across the vegetated project area. Descriptive observations of submersed aquatic vegetation will be noted during monitoring of emergent vegetation. An identical protocol will be followed in the reference area sampling 10 plots. Vegetation will be monitored in 1997 (pre-construction) and in 2002, 2005, 2008, 2011, 2014, and 2017 post-construction in the fall to coincide with aerial photography.
5. Vegetative Plantings The general condition of the vegetative plantings will be documented by monitoring a 5% sample of the plantings from each of the planting groups, using sampling plots for species composition, % cover and % survival. Each sampling plot will consist of 10 plantings labeled with PVC marker poles to mark the location of the plot. These criteria will be documented at 1 month and 6 months after construction in 1999, 2000, 2002, 2005, 2008, 2011, 2014, and 2017, or until plants become indistinguishable.
6. SAV To determine the frequency of occurrence of submersed aquatic vegetation (SAV) between the project area and a reference area, within each study area, two ponds will be sampled for presence or absence of SAV at 25 random points on each line using the rake method (Chabreck and Hoffpauir, 1962). In the original location of Brown Lake, no samples will be taken. Three samples will be taken in the project area, one east of the cells and two west of the cells. Two samples will be taken in the reference area. Species composition and frequency of occurrence will be determined for each pond from the number of points at which SAV occurred and the total number of points sampled. SAV will be monitored in 1997 (pre-construction) and in 2000, 2002, 2005, 2008, 2011, and 2017 post-construction in the fall to coincide with vegetation sampling.
7. Fisheries Fisheries monitoring will be conducted once in 1997 (pre-construction). Sampling periods will occur in late spring, and in the fall when the water level is at or below marsh elevation to eliminate emergent marsh as a habitat type to be sampled. Samples will be randomly selected in each area without regard to habitat, and the data used to estimate both animal densities and habitat coverage for the project and the reference area. Each sampling event will include 30

throw trap (Kushlan 1981) samples for the project area and 30 throw trap samples in the reference area south of the project area. Analysis conducted on the samples will include species composition, number of each species per sample, size of animals, and dry weight or biomass of dominant species.

Anticipated Statistical Analyses and Hypotheses

The following hypotheses correspond with the monitoring elements and will be used to evaluate the accomplishment of the project goals.

1. Descriptive and summary statistics on historical data (for 1956, 1978, and 1988) and data from color-infrared aerial photography collected pre- and post-construction will be used, along with GIS interpretations of these data sets, to evaluate marsh to open water ratios and changes in the rate of marsh loss/gain in the project area. If sufficient historical information is available, regression analyses will be done to test for changes in slope between pre- and post-construction conditions. Habitat mapping data may also be used in the analyses of emergent vegetation, to evaluate the project goal of increasing the occurrence (coverage) of emergent marsh vegetation in the project area, as discussed under item 6 below.

Goal: Increase emergent marsh vegetation by controlling erosion and reclaiming eroded areas.

2. The primary method of analyses for salinity variability will be to differences in mean salinities as evaluated by an analysis of variance (ANOVA) that will consider both spatial (stations) and temporal (day) variation and interaction. The ANOVA model used will be a BACI (Before-After-Control-Impact) type model, which will determine if there are detectable impacts in the project area after construction, (e.g., a decrease in salinity variability). Multiple comparisons will be used to compare individual means across different treatment levels. All original data will be analyzed and transformed (if necessary) to meet the assumption of ANOVA (e.g. normality). The goal can be achieved in two stage hypothesis testing. If H_0^1 is accepted, proceed to stage 2 to determine if the mean salinity is maintained. In both stages, test H_0 at level alpha.

Goal: Decrease annual salinity variability without increasing mean salinity relative to the reference area.

Hypothesis¹:

H_0^1 : Annual salinity variability within the project area post-construction will be significantly lower than annual salinity variability in the reference area after construction.

H_a^1 : Annual salinity variability within the project area post-construction will not be significantly lower than annual salinity variability in the reference area after construction.

Hypothesis²:

H_0 : Annual mean salinity within the project area post-construction will be significantly lower than annual mean salinity in the reference area after construction.

H_a : Annual mean salinity within the project area post-construction will not be significantly lower than annual mean salinity in the reference area after construction.

3. The primary method of analyses for water level variability will be to determine differences in mean water levels as evaluated by an analysis of variance (ANOVA) that will consider *both* spatial and temporal variation and interaction. The basic model of ANOVA will be BACI type model (Before-After-Control-Impact). This model will determine if there is detectable impact (e.g., decrease in water level variability) in the project area after construction. Multiple comparisons will be used to compare individual means across different treatment levels. All original data will be analyzed and transformed (if necessary) to meet the assumption of ANOVA (e.g. normality). When the H_0 is not rejected, the possibility of negative effects will be examined. The goal can be achieved in two stage hypothesis testing. If H_0^1 is accepted, proceed to stage 2 to determine if the mean salinity is maintained. In both stages, test H_0 at level alpha.

Goal: Decrease annual water level variability without increasing mean water level relative to the reference area.

Hypothesis¹:

H_0 : Annual water level variability within the project area post-construction will not be significantly lower than annual water level variability within the reference area after construction.

H_a : Annual water level variability within the project area post-construction will be significantly lower than annual water level variability within the reference area construction.

Hypothesis²:

H₀: Mean water level within the project area post-construction will not be significantly lower than mean water level within the reference area after construction.

H_a: Mean water level within the project area post-construction will be significantly lower than mean water level within the reference area construction.

4. The primary method of analyses for emergent vegetation will be to determine differences in mean vegetation cover as evaluated by an analysis of variance (ANOVA) that will consider both spatial and temporal variation and interaction. The basic model of ANOVA will be BACI type model (Before-After-Control-Impact). This model will determine if there is detectable impact (e.g., increase in vegetation cover) in the project area after construction. Multiple comparisons will be used to compare individual means across different treatment levels. All original data will be analyzed and transformed (if necessary) to meet the assumption of ANOVA (e.g. normality). When the H₀ is not rejected, the possibility of negative effects will be examined.

Goal: Increase the occurrence (coverage) of emergent marsh vegetation in the project area.

Hypothesis:

H₀: occurrence of emergent vegetation within the project area post-construction will not be significantly greater than occurrence of emergent vegetation within the reference area after construction.

H_a: occurrence of emergent vegetation within the project area post-construction will be significantly greater than occurrence of emergent vegetation within the reference area after construction.

5. The primary method of analyses for vegetative plantings will be to determine differences in mean vegetation cover as evaluated by an analysis of variance (ANOVA) that will consider both spatial and temporal variation and interaction. The basic model of ANOVA will be BACI type model (Before-After-Control-Impact). This model will determine if there is detectable impact (e.g., increase in vegetation cover) in the project area after construction. A repeated measure design will be used in the ANOVA model. Multiple comparisons will be used to compare individual means across different treatment levels. All original data will be analyzed and transformed (if necessary) to meet the assumption of ANOVA (e.g. normality). When the H₀ is not rejected, the possibility of negative effects will be examined.

Hypothesis:

H_0 : Vegetative cover within the project area will not be significantly higher than vegetative cover within the project area after construction.

H_a : Vegetative cover within the project area will be significantly higher than vegetative cover within the project area after construction.

6. Within a given sampling period, the Wilcoxon-Mann-Whitney Test will be used to test the hypothesis that there is no difference between the median frequency of SAV in the project area and the median frequency of SAV in the reference area (Siegel and Castellan 1988:128-137).

Goal: Increase frequency of occurrence of SAV.

Hypothesis:

H_0 : Frequency of SAV in the project area at any time point i is not significantly greater than the frequency of SAV in the reference area at any time point i .

H_a : Frequency of SAV in the project area at any time point i is significantly greater than the frequency of SAV in the reference area at any time point i .

Repeated Measures Analyses will be used to compare the frequency of SAV between the project area and the reference area (Steele and Torrie 1980:377-437). These data will likely require transformation because percentage data with ranges between 0 and 20 or 80 and 100 often follow the Poisson distribution (Steele and Torrie 1980:3234-238). The square root plus 0.5 and the arcsin transformations are the most likely to correct heterogeneity of error associated with percentage data.

Hypothesis:

H_0 : Frequency of SAV in the project area over time is not significantly greater than the frequency of SAV in the reference area over time.

H_a : Frequency of SAV in the project area over time is significantly greater than the frequency of SAV in the reference area over time.

7. Descriptive and summary statistics for fisheries data will include species composition, number of each species per sample, size of animals, and dry weight or biomass of dominant species. Ancillary data (i.e. herbivory, historical) will be used when available. This additional information may be evaluated through analyses such as: correlation, trend, multiple comparisons, and interval estimation. If the null hypothesis is rejected, both

positive and negative effects will be examined to determine abundance in the project versus the reference area.

Goal: *Maintain fisheries abundance.
(*Fisheries abundance will be measured through biomass, density of organisms and species richness)

NOTE: Available ecological data, including both descriptive and quantitative data, will be evaluated in concert with the statistical analysis to aid in determination of overall project success. This includes ancillary data collected in the monitoring project but not used directly in statistical analysis, as well as data available from other sources (USACE, USFWS, DNR, LSU, etc.).

Notes

1. Implementation: Start Construction: October 1, 1998
End Construction: April 1, 1999
2. NRCS Point of Contact: Gary Eldridge (318) 473-7685
3. DNR Project Manager: Garrett Broussard (318) 893-8763
DNR Monitoring Manager: Dona Weifenbach (318) 893-2085
DNR DAS Assistant Mary Horton (504) 342-4122
4. The twenty year monitoring plan development and implementation budget for this project is \$820,564. Progress reports will be available in April 2000, April 2001, April 2003, April 2004, April 2006, April 2007, April 2009, April 2010, April 2012, April 2013, April 2015 and April 2016, and comprehensive reports will be available in April 2002, April 2005, April 2008, April 2011, April 2014, and April 2019. These reports will describe the status and effectiveness of the project.
5. Pre-construction monitoring of salinity and water level was initiated in August, 1996 by DNR.
6. References:

Chabreck, R. H., and C. M. Hoffpauir 1962. The use of weirs in coastal marsh management in coastal Louisiana. Proceedings of the Annual Conference of the Southeastern Association of Game Fish Commissioners. 16:103-12. Columbia, South Carolina.

Chabreck, R. H., and G. Linscombe 1978. Vegetative type map of the Louisiana coastal marshes. Louisiana Department of Wildlife and Fisheries, New Orleans.

- Kushlan, J. A. 1981. Sampling characteristics of enclosure fish traps. *Transactions of the American Fisheries Society* 110:557-62.
- O'Neil, T. 1949. Map of the southern part of Louisiana showing vegetation types of the Louisiana marshes. Louisiana Department of Wildlife and Fisheries, New Orleans.
- Siegel, S., and N. J. Castellan 1988. *Nonparametric statistics for behavioral sciences*. New York: McGraw-Hill, Inc., 2nd edition. 384 pp.
- Steele, R. G. D., and J. H. Torrie. 1980. *Principles and procedures of statistics: a biometrical approach*. New York: McGraw-Hill, Inc. 633 pp.
- Steyer, G. D., R. C. Raynie, D. L. Steller, D. Fuller, and E. Swensen 1995. *Quality Management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring program*. Open-file series no. 95-01. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division.
- Suhayda, J. N., M. Alawady, and B. Naghavi 1993. *Water level statistics for design of transportation facilities in coastal Louisiana*. State Project No. 736-15-0081 vol. 1. Baton Rouge: Louisiana Transportation Research Center.
- United States Department of Agriculture (USDA), Soil Conservation Service. n.d. *Soil Survey Maps 5, 6, 20, 21, 35, and 36 (based on 1982 aerial photography) for Cameron Parish, Louisiana*. Washington, D.C.:U.S. Government Printing Office. Scale 1:20,000.
- United States Department of Agriculture, Natural Resource Conservation Service (NRCS) 1996. *Project Plan and Environmental Assessment*. Alexandria, Louisiana: Water Resources Office. 30 pp, plus 4 figures and 1 appendix.